Lidar Soundings of Noctilucent Clouds during the PMC Turbo Balloon Mission

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Noctilucent Clouds at 83 km Altitude

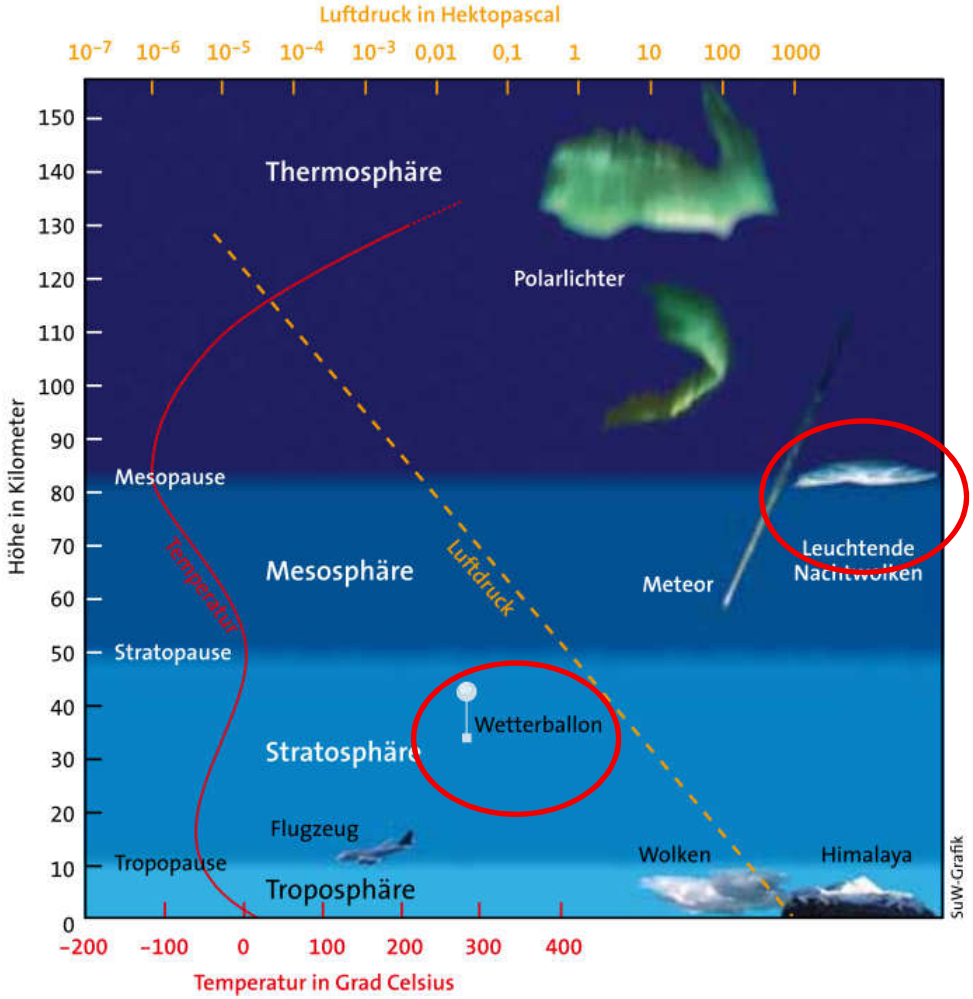
Low polar summer mesopause temperatures

→Formation of thin ice layers

PMC Turbo mission (NASA/DLR)

→High-resolution observations from a stratospheric platform using the Balloon Lidar Experiment BOLIDE and cameras

→Study breaking gravity waves, instabilities and turbulence



PMC Turbo Flight from Esrange to Canada in July 2018

Fritts et al., PMC Turbo: Studying Gravity Wave and Instability …, Journal of Geophysical Research, 2019

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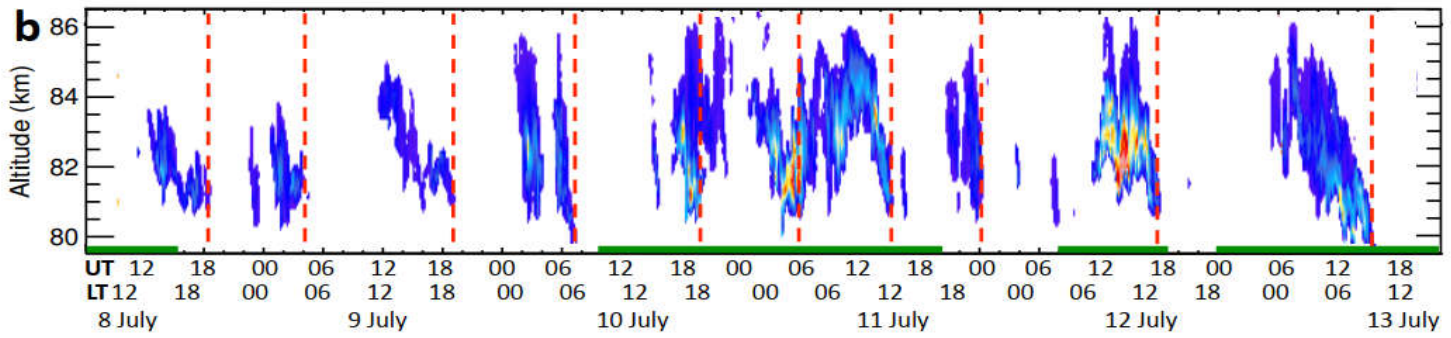


Fritts et al., JGR, 2019

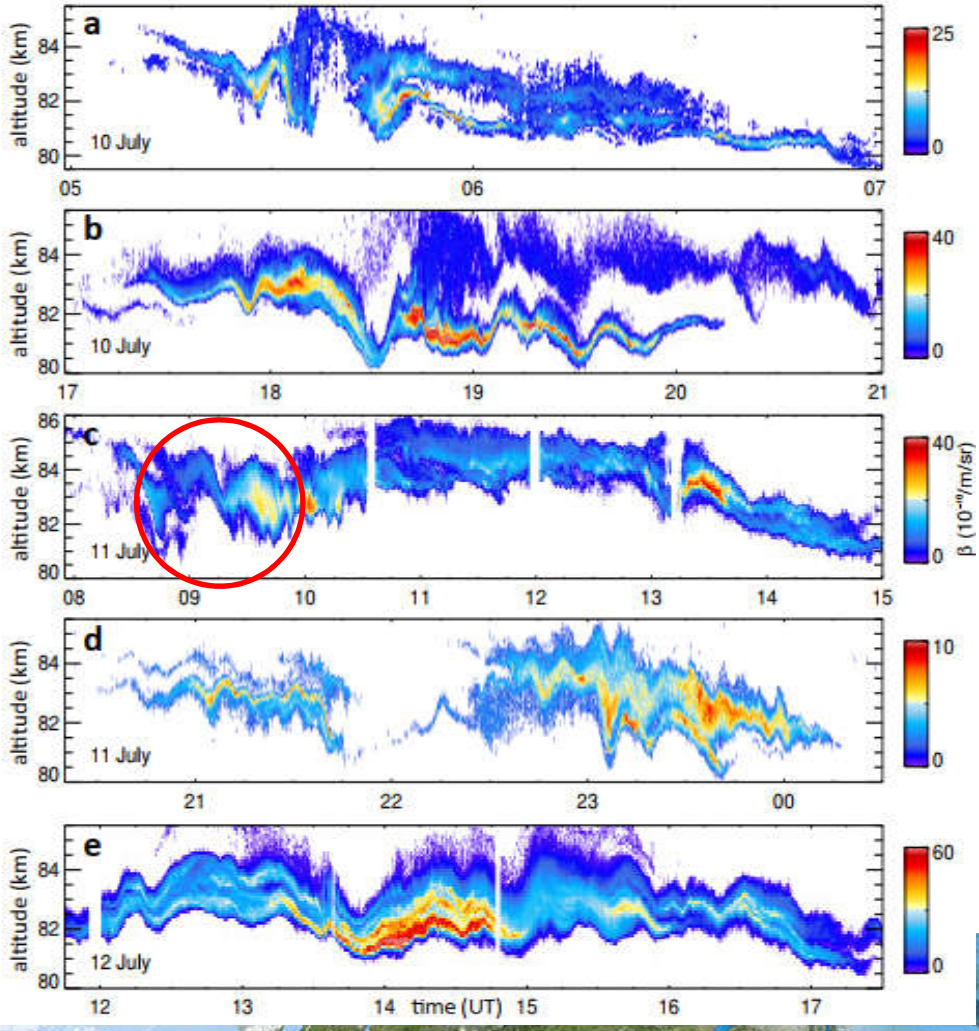
NLC Layer Measurements

- 70 h, ~50 % occurrence frequency
- Maximum brightness above 90 $\cdot 10^{-10}$/m/sr
- Resolution of 20 m x 10 s

→ more than 25,000 NLC profiles

+ mesospheric gravity waves from T‘

+ 3,000,000 camera images of NLC



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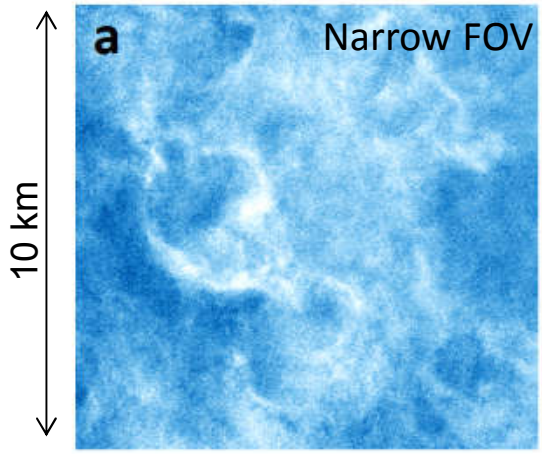
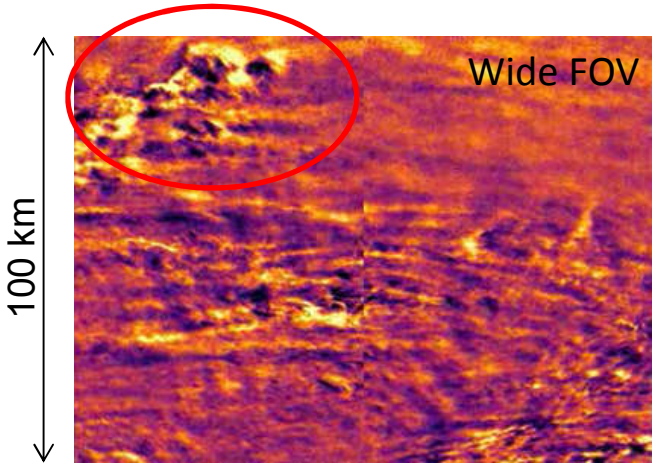
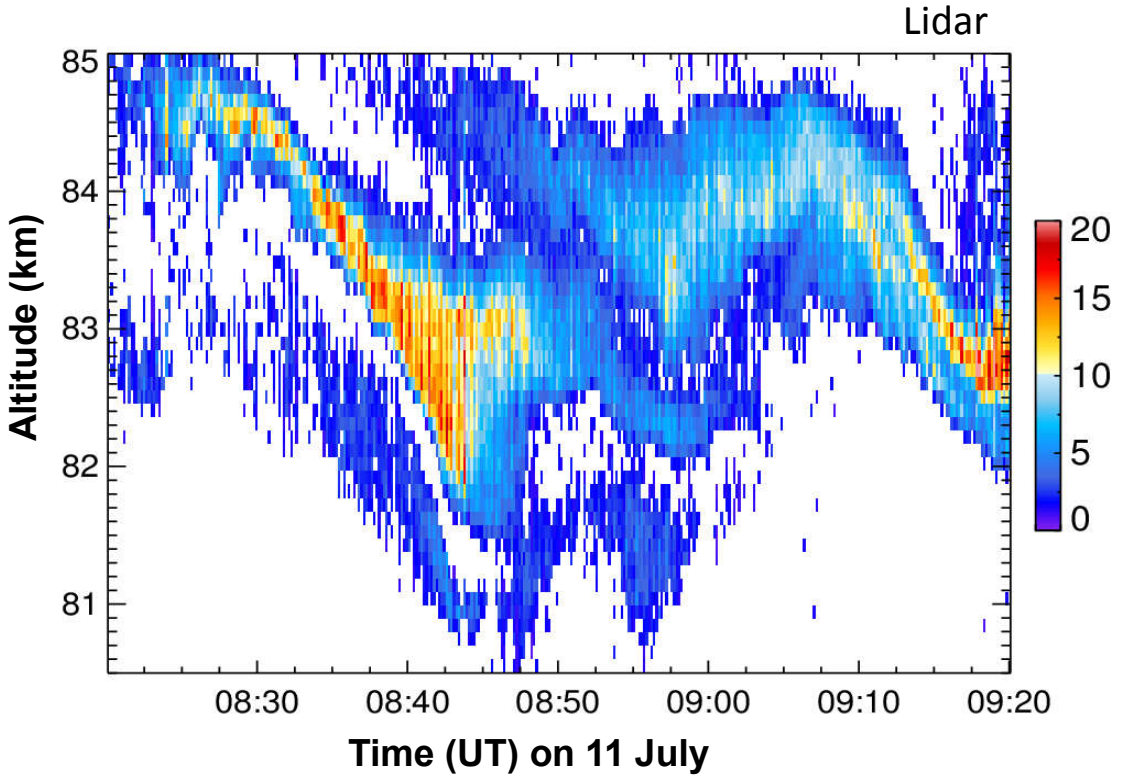
I. Vortex rings on 11 July







- Streamwise vortex linkages between adjacent rings along GW propagation direction
- Vortex rings of 2-4 km diameter

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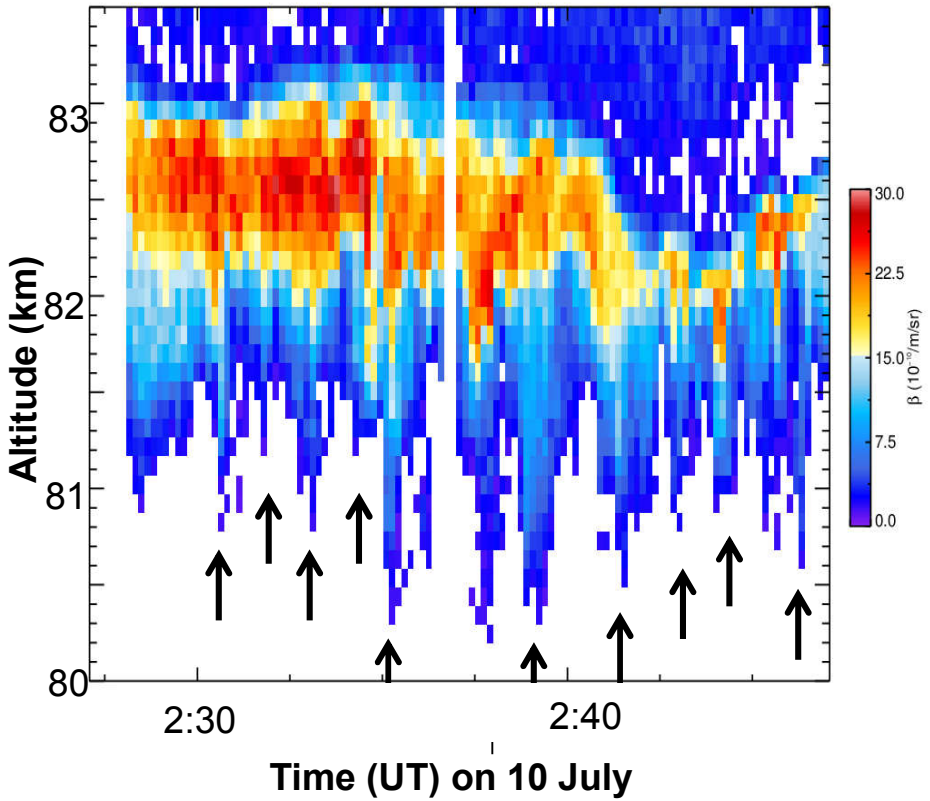
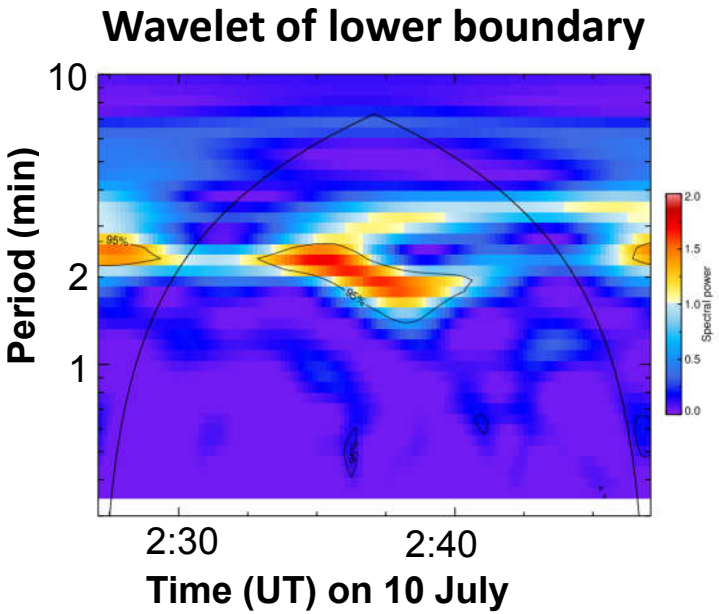
II. Small-scale Vortex Rings on 10 July





2 min period oscillation of lower PMC boundary

→ ~1 km horizontal scale

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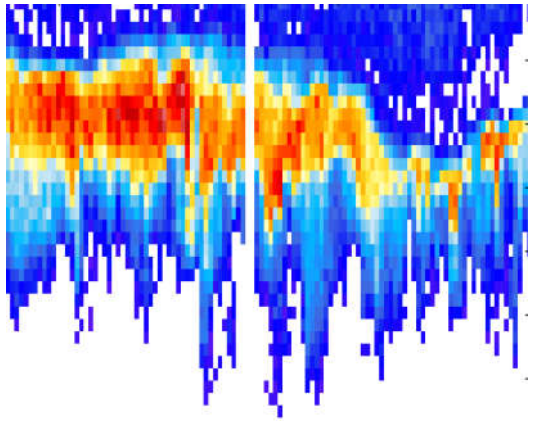
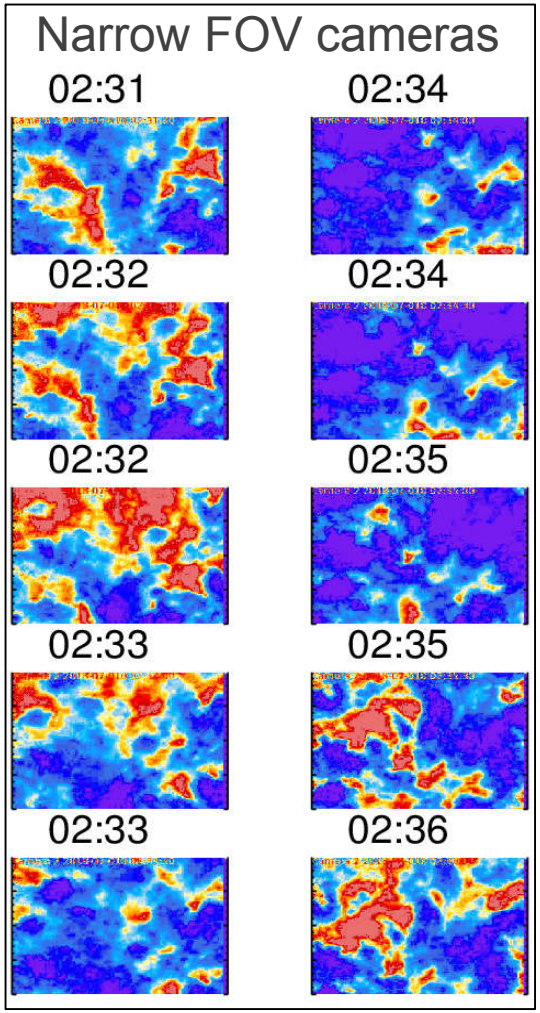
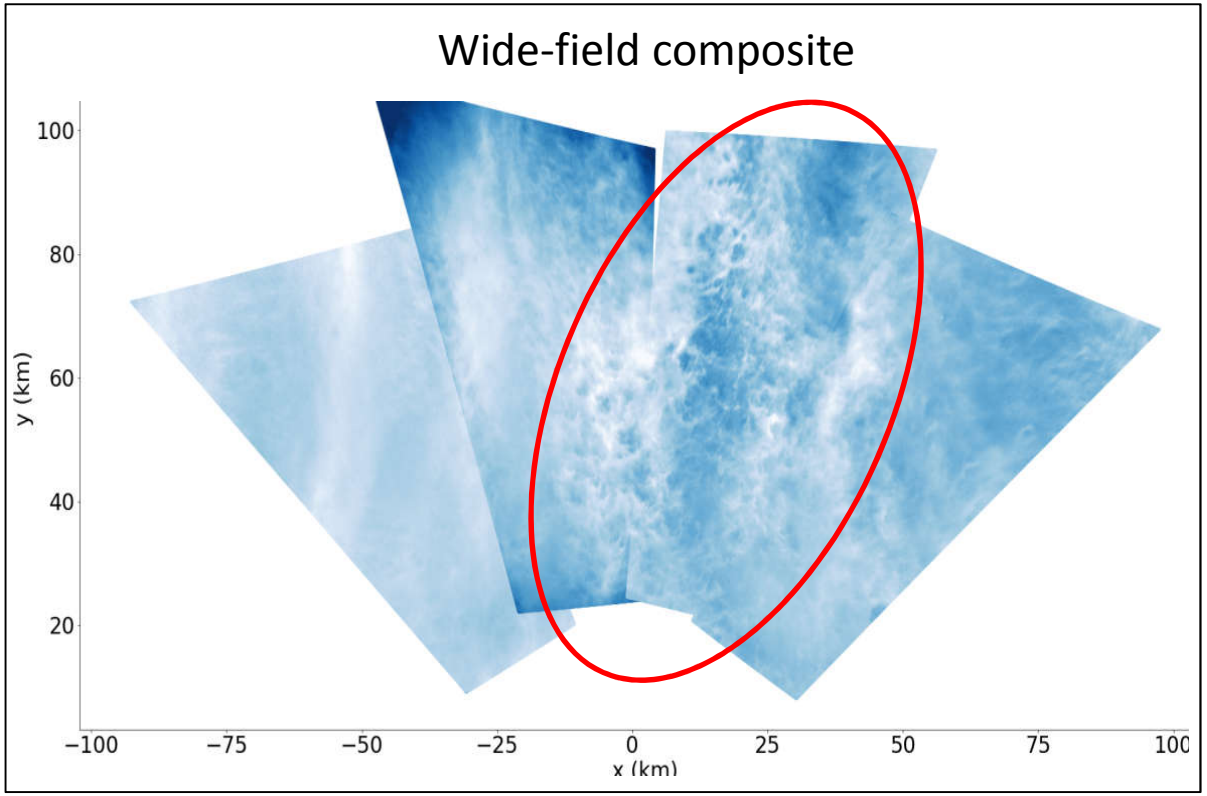




Small-scale vortex rings due to multiple interacting GW



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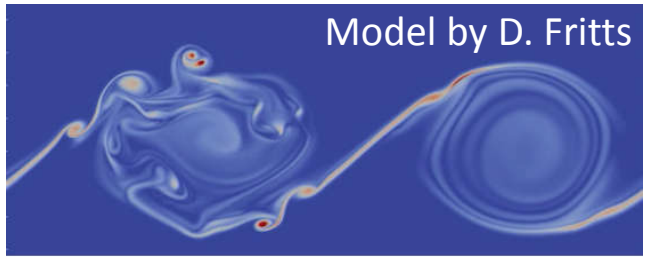
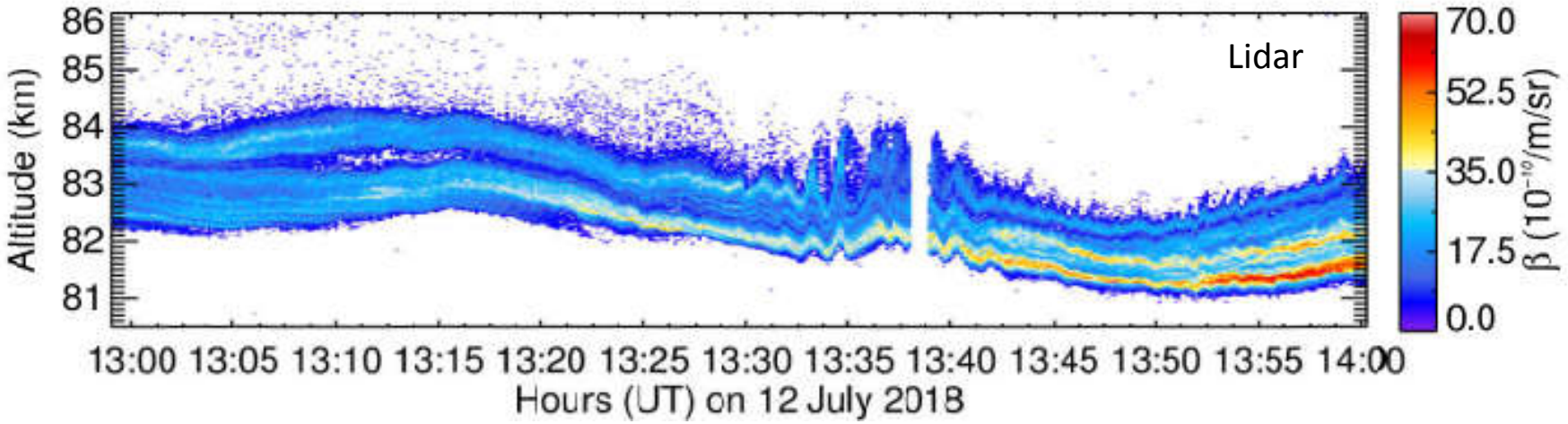
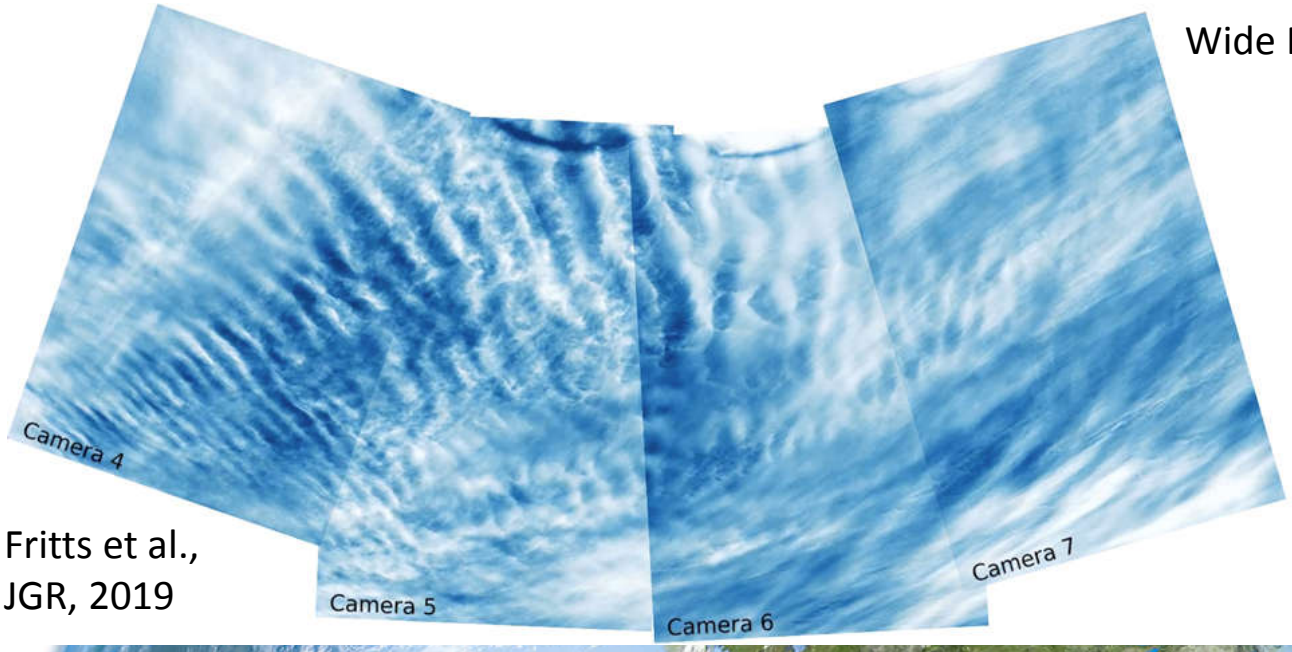
III. Kelvin-Helmholtz Instability on 12 July





Breaking GW induce strong KH instabilities with secondary KHI and inter-billow interaction

Wide FOV



Fritts et al., JGR, 2019

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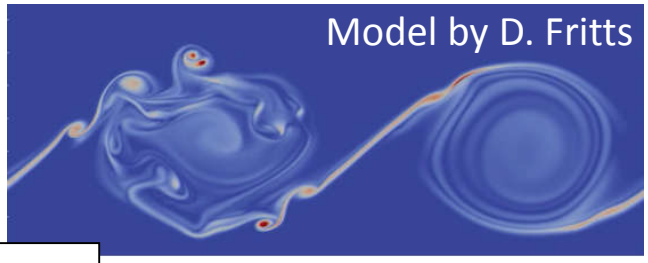

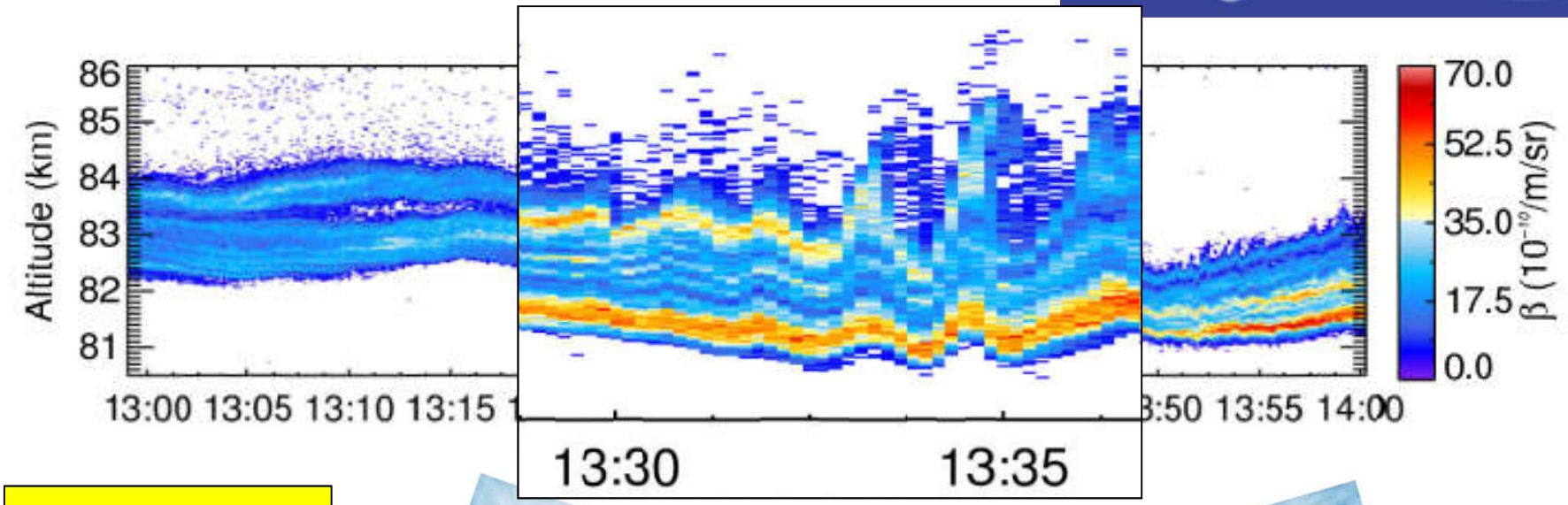

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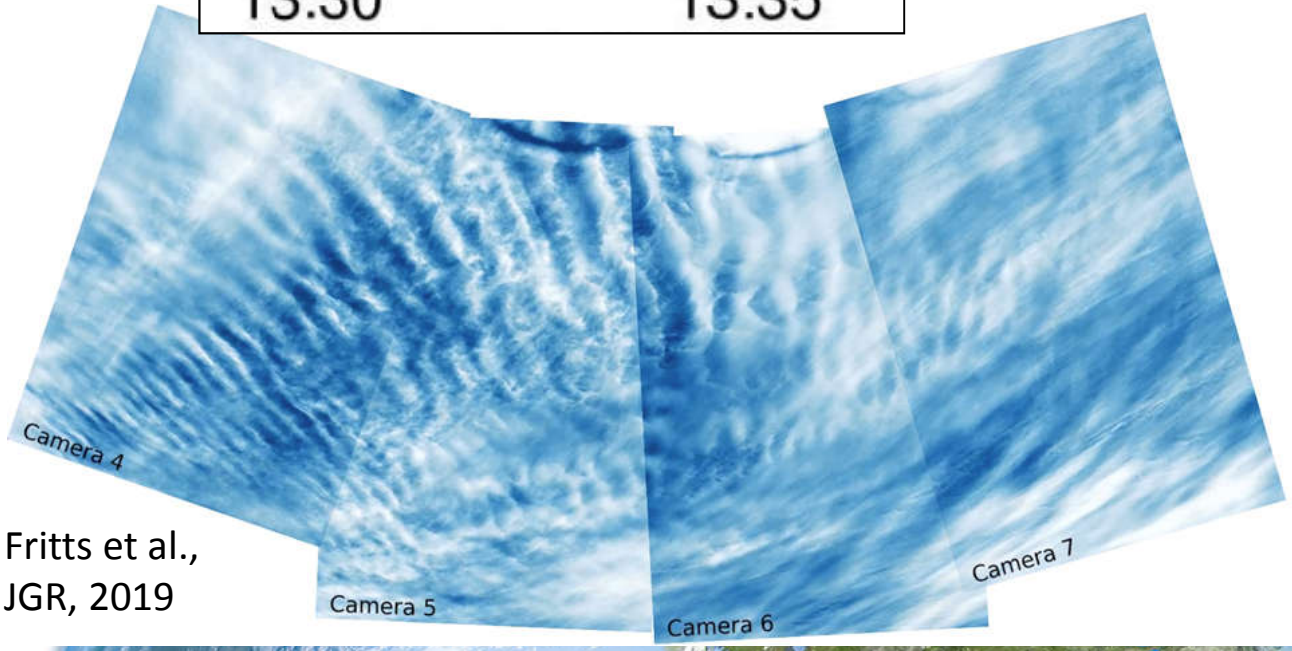

Fritts et al., JGR, 2019

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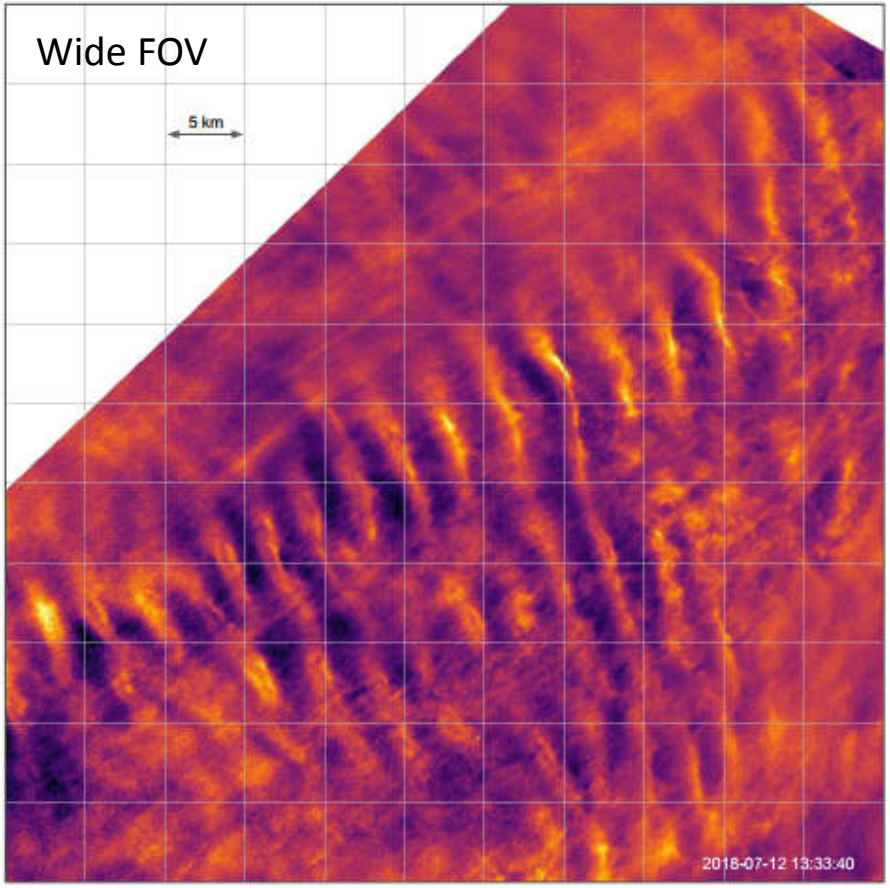
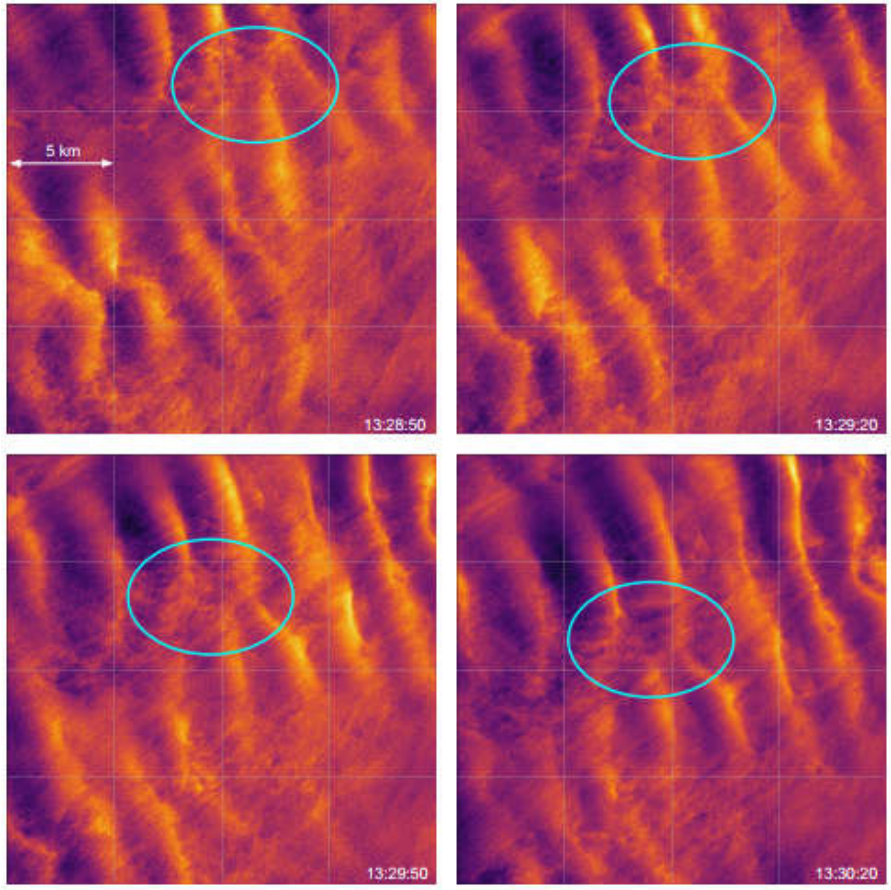
III. Kelvin-Helmholtz Instability on 12 July

Kjellstrand et al., in preparation





Secondary KH instablities and twist waves

Merging KH billows with knots and tubes

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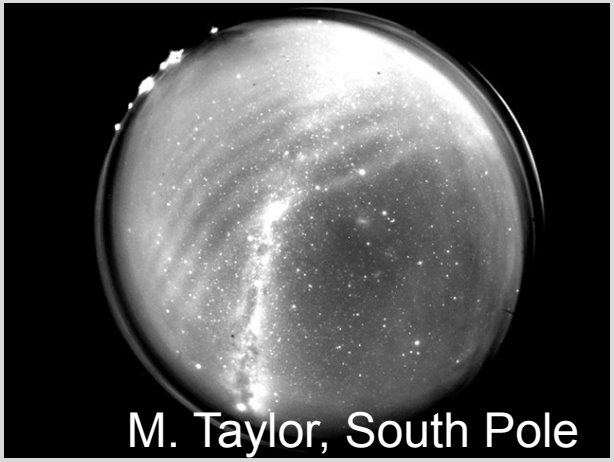
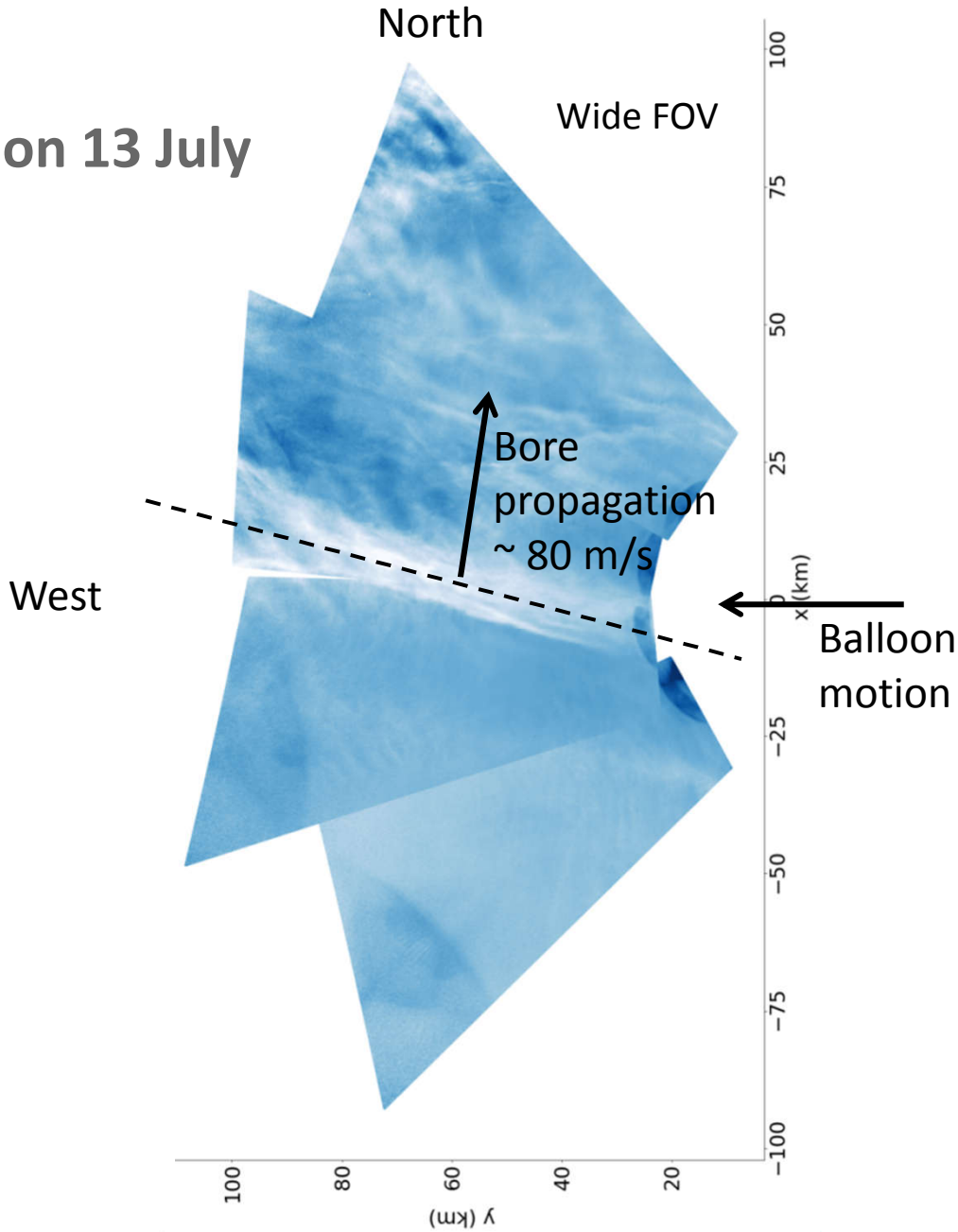
IV. Mesospheric bore event on 13 July



Previous bore observations on water and in OH images



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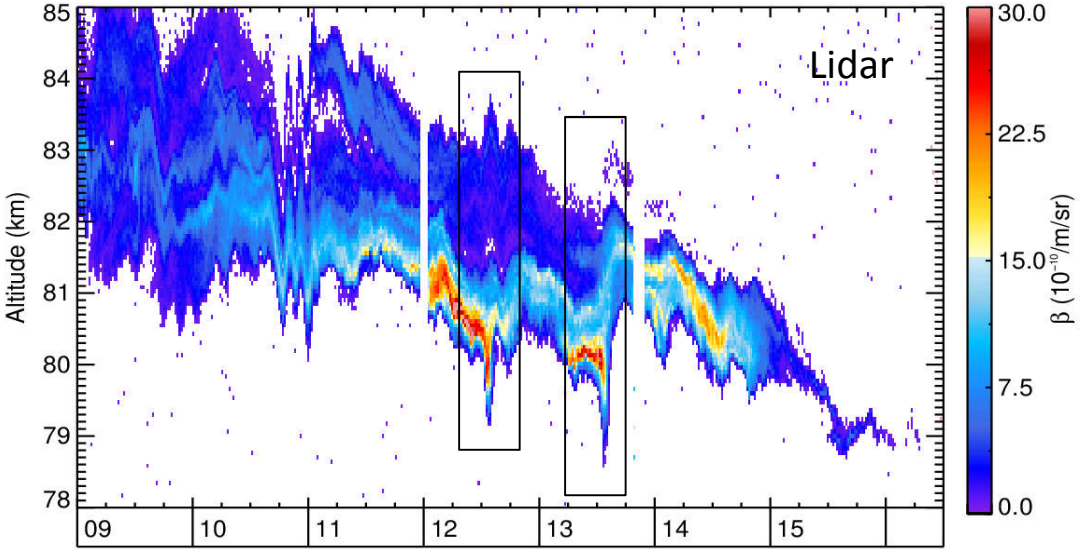
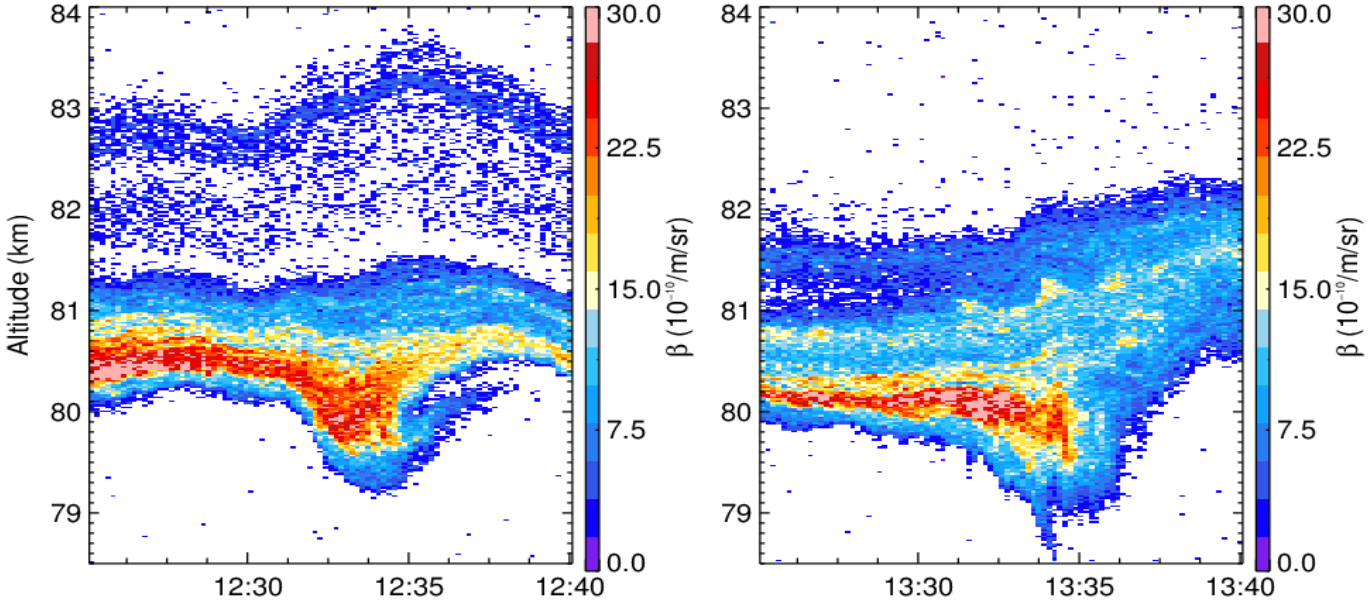
IV. Mesospheric Bore Event on 13 July

First high-resolution observations of bore dynamics





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Images were produced with funding from
NASA 80NSSC18K0050

Summary

- Balloon lidar experiment BOLIDE: First mesospheric lidar on a balloon
- PMC Turbo: High-resolution observations of the Noctilucent Cloud layer for studying breaking **gravity waves, instabilities and turbulence**
- 6-day flight in the northern hemisphere yielded a unique dataset with a large number of interesting events

- Pre-press: Fritts et al., JGR, 2019
- Instrument and science papers in preparation

- Possible second flight from Antarctica

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